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Operations Planning Tools (OPT) Functional Description

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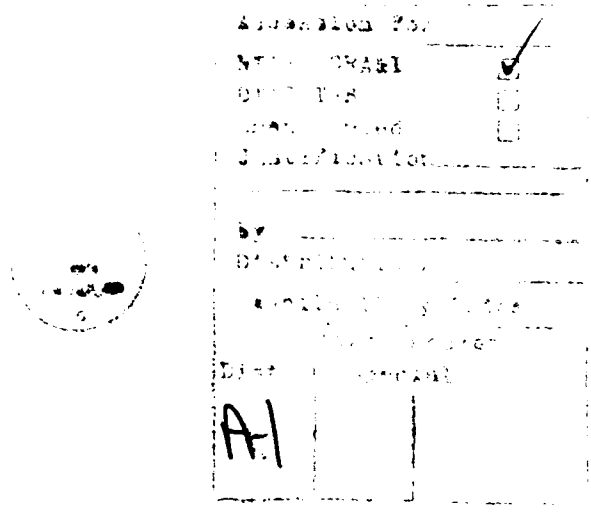

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The Operations Planning Tools (OPT) are an integrated set of aids to assist Army tactical planners in developing and evaluating courses of action. This report describes the background of, concepts for operation, and functional capabilities of OPT. The concepts for OPT were generated from an analysis of combat staff officers performing critical planning tasks. Functions were allocated to the planner and to the computer support tools according to relative strengths and weaknesses. OPT was designed to provide support in visualization, computing estimates, and information management functions to support rapid revisions in encoded concepts and projections of battle outcomes.

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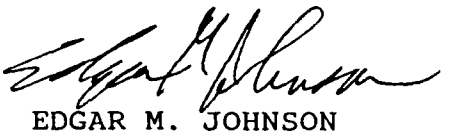
Human Performance Effectiveness and Simulation

FOREWORD

This report describes the capabilities of a prototype set of staff planning tools--Operations Planning Tools (OPT). OPT was created in association with the development of the Tactical Planning Workstation at the Fort Leavenworth Field Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI). OPT was developed using a thorough front-end analysis of soldier-based requirements for tactical planning. The analysis projected that the most useful staff aiding tools would be those that could support the soldier by being responsive to what they wanted to plan, to the level of detail that they wanted to plan, and within the available time to plan. The OPT concepts have resulted in operational prototype software. OPT has undergone user assessments by members of the command and control combat developments community and, as a result, future command and control requirements are being generated.



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OPERATIONS PLANNING TOOLS (OPT) FUNCTIONAL DESCRIPTION

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OPERATIONS PLANNING TOOLS (OPT)
FUNCTIONAL DESCRIPTION

Purpose

The Fort Leavenworth Field Unit of the U.S. Army Research Institute (ARI) has developed the Experimental Development, Demonstration, and Integration Center (EDDIC) to conduct research in command and control (C2) and human performance. The EDDIC equipment and facilities have been used to investigate issues related to the enhancement of human performance of C2 activities, primarily at the division echelon. The Tactical Planning Workstation is an integral part of the EDDIC environment. The Workstation[1] features provide staff officers with automated support to enhance information processing and decision making required for tactical planning. The Workstation provides a stimulus to examine tactical computer system requirements and staff planning issues. A set of planning tools called Operations Planning Tools (OPT) were developed for the Workstation to assist in course of action (COA) development, analysis, and selection process.

The concepts for OPT came from a front-end analysis of tactical planning. The analysis started with reviewing the task requirements of tactical planning and selecting broad concepts for aiding (Carter, Archer & Murray, 1988). The analysis included observations of many instances of staff or individuals involved in tactical planning (e.g., Defense Systems Incorporated, in preparation; Fallesen, Michel & Carter, 1989; Keene, Michel & Spiegel, in preparation; Thordsen, Galushka, Klein, Young & Brezovic, 1989; Thordsen, Klein, Michel & Sullivan, in preparation). These observations suggested that the tactical planning process is a highly variable activity that depends on many factors, including the experience of the planners, the time available to plan, the command climate, the planners' tendencies to be analytical or intuitive, and their preferences for level of organization in their work. There was enough evidence to indicate that observed performance differs noticeably from the planning process found in doctrinal and training materials and taught to officers (Fallesen et al.; Michel, in preparation). The implications of these observations for designing decision support tools are discussed in the following sections.

The primary purpose of this report is to provide the background that led to the OPT development and a description of the OPT concept and functional capabilities.

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[1] Throughout the remainder of the document, the Tactical Planning Workstation will be referred to as the Workstation.

C2 Problems and Needs Related to OPT

Problems in tactical decision making stem from the battlefield environment, current command and control procedures, and limitations in human capabilities related to information management and decision making. The tactical battlefield environment will impose severe time pressures and demands on the staff and commander. Enormous volumes of information will be generated by a rapidly changing environment. This will be complicated by the need to synchronize multiple operations across the battlefield.

Tactical planning is complex because of the vast intricacy of the problem domain, short time constraints, and human's limited abilities to perform consistently at high levels. Humans are subject to many cognitive limitations (see Table 1). It is vital that these limitations be understood so they can be corrected or aided through training and decision support programs.

Table 1

Examples of possible cognitive limitations in tactical planning.

Insufficient knowledge about task procedures.
Inappropriate selection of procedures.
Failure to identify, prioritize, and assess goals.
Procedures not performed in a standard fashion.
Poor balance of depth and breadth of alternatives.
Failure to consider alternatives thoroughly.
Detailed analysis early, too little detail late.
Difficulty in symbolic manipulations and transformations.
Low computational capacity.
Improper matching (stereotyping).
Failure to distinguish key differences among cases.
Failure to generalize from experience to specific cases.
Difficulty dealing with abstractions.
Variable deductive skills.
Failure to wargame.
No basis for projection of battle outcomes.
Failure to identify salient aspects of information.
Failure to evaluate, compare, and combine salient information.
Inappropriate revision when faced with new information.
Under-emphasizing inconsistent, ambiguous information.
Relying too heavily on concrete information.
Limited skill in organizing information.
Poor handling of uncertainty.
Failure to recognize errors.
Inadequate factual knowledge in task domain.

Time Pressures

Tactical planning is not an easy task, and performance has been observed to be deficient in various ways. Planning requirements are impacted by the characteristics of the situation and the time available, both of which can vary greatly. Some situations require very quick planning because of an urgent, impending threat or sudden awareness of unanticipated events. Other situations require detailed consideration because there has been no prior opportunity or need for analysis for some specific mission. Often both cases occur; when radically, new plans are needed, with very little planning time available.

Variable Procedures

The time constraints of the tactical environment challenge the capabilities of the staff and commander to follow a logical, orderly, and analytical process for decision making[2]. Tactical decision making is not always performed using the processes prescribed by U.S. Army literature (Fallesen et al.). Processes do not always follow an orderly or systematic manner. Steps in the decision making process are often not performed or not completed. Sometimes critical steps are performed concurrently; for example, planners may perform COA development, evaluation, and comparison at the same time.

While training and modified procedures are some of the means to correct these problems, it is clear that the dynamic and ever-changing nature of the combat environment requires planners to be flexible in performing their activities.The great variability in planning procedures and knowledge used creates more challenging conditions in which to know what performance is desirable and to develop flexible aiding approaches.

Depth vs. Breadth

It is difficult for staff members to achieve the appropriate balance between depth and breadth of tactical considerations during planning. For example, emerging results from experiments in COA analysis (e.g., Fallesen et al.) indicate that staff members may spend considerable time conducting a detailed analysis early in the process. In latter phases, there may be insufficient time for a detailed analysis of recently refined options. As the decision tree grows in an unbounded manner,

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[2] It should be noted that ST 100-9 (1989) does not impose an ordered sequence of steps for performing the command estimate. The process is not considered "cut-and-dry", there are not necessarily distinct start and stop points, and all elements are not independent (p. 1.3). The estimate process is considered "a personalized tool to aid in decision making (p. 6.2)."

decision options or alternatives are rarely tested for feasibility or analyzed in the level of detail used for earlier options. This may be an appropriate response. Detail in early stages of planning may help to develop a fuller understanding of the situation and to reduce uncertainty. Planning tools must adapt to the depth and breadth that the situation dictates and should offer assistance in feasibility testing regardless of the time available.

Level of Detail

There are also differences among planners in the amount of detail they feel compelled to consider when planning. Officers with little experience may try to be as certain as they can be, because they realize that they are unfamiliar with important aspects of tactics or have little basis for projecting outcomes. Experienced officers have more confidence and may tend to focus on the critical aspects of planning. Biases may affect performance when self-assessments of ability are incorrectly matched to the level of planning detail required. Planning can be deficient when the inexperienced officers plan shallowly, or even when experienced officers do not recognize the proper relationships among battlefield events and battlefield operating systems. Perhaps one of the most critical results of planning in compressed time is the tendency to ignore details. Tools should help deal with the detailed planning considerations.

Visualization

Visualization of the battlefield is a critical requirement for predicting future situations, critical events, and battle outcomes. This requires the planner to predict interactions between enemy and friendly forces on a complex battlefield environment affected by factors to include weather, terrain, and visibility conditions. It is difficult for humans to visually project in time and space (Wishart, 1990; Zachary, 1988). War-gaming and projecting battle outcomes are also difficult for planners. "Visions" of the current and future situation require well trained and highly experienced personnel to conduct activities requiring complex information processing and cognitive skills. Despite these requirements, only a small percentage of staff officers have prior combat experience. Training to provide officers with experience often results in mixed results because of the low fidelity of combat realism or lack of diagnostic feedback in exercises (Crumley, 1989; Kaplan, 1987). Computer-based systems can effectively enhance the planner's "vision" of the battlefield and provide projections of battle outcome measures (e.g., friendly and enemy losses, ground movement).

Summary

As a result of these characteristics of the planning task, the specifics of a situation, and human limitations, the level of deliberate analysis that should go into producing good plans is often not accomplished. There is a need to provide support to the planner in those areas where humans are less well suited than computers to perform selected activities.

Aiding Approach

Functions that computerized tools are capable of supporting were identified from an understanding of the task requirements, typical performance on the task, cognitive problems of performance, and constraints of how users seem to best interact with computer systems. Aiding concepts were produced from how computer tools could best provide support relative to what humans do best.

Desired Functional Support Criteria

Presentation Support for Aiding Visualization. Computers deal well with detailed information: keeping track of unit designations, types, strengths, locations, and dispositions. Computers are good for displaying this information over terrain maps with battlefield control measures. The display of information on units and terrain, along with projected battle events, helps to provide a visualization of time and space relationships of the battle. OPT was designed to support this need.

Computational Support for Aiding Estimates. A computer's ability to handle quantities of data, processing that data in pre-specified ways quickly, and performing those processes repetitively in a highly reliable fashion makes the computer the logical candidate for mathematical computations. The typical human, who is prone to errors in mathematical computations, oversight of factors, and memory limitations, usually prefers not to engage in tasks requiring a great many calculations. OPT off-loads the memory and computational work from the human and provides rapid computations of combat power ratios, time-distance estimates for movements, and unit attrition estimates.

Organizational Support for Aiding Information Management. Computers are generally better at storing coded information more accurately and completely than humans. Once stored, the computer can be used as a tool to retrieve information and process it in various ways. The computer should represent information in natural and familiar ways, otherwise it may do more harm than good. OPT was designed to provide a means to store quantitative and visual results from course of action evaluations in ways that are familiar to planners. Once the information is available and organized, it can be processed and manipulated more readily than if done by manual means. OPT can be used for exploring or refining courses of action, comparing courses of action, generating branches or sequels, testing various assumptions, and estimating acceptable performance levels through sensitivity analyses. The ability to easily manipulate information stored as logical units allows the planner to refine tactical concepts and test them iteratively.

Desired OPT-User Interaction Criteria

One purpose of OPT is to augment human performance by providing support tools that soldiers can use to leverage the things they do well and that computers do not do as well. For example, special abilities that humans have include being able to solve varied problems, reason inductively (generalize from observations), and respond to novel or unusual situations. Some specific design criteria allowing OPT to adapt to the human strengths and style of performance are as follow:

Adaptable. The philosophy of OPT is to support performance in a manner that is adaptable to the way a planner wants to do planning, not the way that the computer has been pre-programmed to do it. Different staffs and individuals use different approaches to planning. Situation and time availability also dictate how planning can and should proceed. For these reasons a set of tools was developed, rather than a decision aid that would try to have the planner mimic some notional, ideal expert or some stepwise process.

User control. Control of the planning process is retained with the soldier, not shifted to the computer tool.

Reduce workload. Many computer tools shift the nature of what the user has to do from mental work to data entry. In these tools the type of work may have been changed to simplify the human task, but the workload may not have been decreased and quite possibly it has increased. An increase in errors is also likely with poorly designed tools. OPT was designed to minimize the workload of data entry to the greatest extent possible. It is also important to keep data entry to a minimum so OPT can be used when there is very little time available for planning.

Familiarity. OPT is based on simple models of combat and wargaming. These may already be familiar to the user through training and doctrine experience. If the user is not familiar, OPT's simplicity allows the models to be readily understood.

Improve performance. OPT's main purpose is to improve performance. The functions that OPT supports suggests that OPT could be useful for speeding planning, increasing the completeness or thoroughness of planning, increasing planning accuracy, decreasing uncertainty, or increasing the quality of the plans in other ways. These goals were recognized throughout OPT's design and development.

Tactical Planning Workstation

The Tactical Planning Workstation (Flanagan & Fallesen, in publication) was the host platform for the applicaiton of the OPT concepts. The Workstation was designed as a vehicle in which to conduct human performance research in command and control. The Workstation provided an existing computer environment to develop OPT on and a set of information management capabilities that OPT could use.

The Workstation provides automated support to allow staff users to find, retrieve, utilize and compare reference and tactical situation information. Reference information consists of selected typical task organizations, equipment loads and capabilities, and other planning factors for both friendly and enemy forces. Tactical situation information includes orders, reports, summaries, estimates, and unit status and location data for the ongoing conflict. This information is presented in both alphanumeric and graphic form. Graphic data include map displays and tactical overlays. Map types include vegetation, shaded relief, elevation contours, and cross-country mobility. The Workstation also supports the staff in developing products using the reference and situation information. The user can enter and manage alphanumeric and graphic information when building products.

While the Workstation is not intended to resolve all the problems associated with tactical decision making, the Workstation contains several tools and aids to enhance the information management and decision making process of the user. These tools have the potential to improve the quality of the decision by providing automated support for a user for planning activities associated with deciding upon and justifying a COA. For example, a Course of Action Assessment Tool (COAAT) (Ross, 1990) provides automated support to select and assign critical battle events, to conduct a detailed analysis of various COAs, and to summarize and compare results to support selection of the preferred COA. COAAT displays automated spreadsheets that provide structure, organization, and basic calculation support for analyzing and comparing alternative COAs. (OPT was developed as an alternative to COAAT, not as an adjunct to it.)

Information processing and management are also supported by the Workstation.

OPT Concept

OPT provides automated support to the operations planning element for developing, analyzing, selecting, and justifying a COA. When using OPT, the planner is in control of the planning process. The design of OPT allows the user to perform the planning activities that he wants to perform in the sequence he wants to perform them. OPT does not impose either step-wise or rule-based procedures on the planning process. A rigid, computer-led approach to problem solving is not imposed on the planner. The planner can control the depth and breadth of COA development based on tactical requirements.

OPT provides the planner with the tools to enhance the capability to conduct planning activities. OPT does not automatically generate COAs for the planner. Rather, OPT provides the support required by the planner when he wants to develop COAs and perform war-gaming. The user will determine how he wants to plan and OPT will be available for support.

Variable Level of Detail

OPT supports a "quick and dirty" analysis as well as a more detailed analysis. Each COA can be specified using varying degrees of detail as determined by the number of routes and segments used to define a COA. Each COA is composed of one or more routes and each route is made up of one or more segments. The planner may choose to conduct an analysis at a very general level of detail by developing a limited number of routes and segments, or he may conduct a detailed analysis by breaking the COA down into a relatively large number of routes and segments. For example, for a quick computation of combat power ratios the planner needs to only specify a straight line route between forces, designate friendly and enemy units involved, and their specific strengths and combat roles. A finer detailed analysis for this same course of action might include breaking that gross-level route into multiple routes with multiple segments which make more logical use of the terrain. The finer detail would provide better estimates of movement times, and combat roles could be assigned with more precision.

Combat Model

OPT uses a simplified model of combat that provides consistent evaluations of alternative COAs. The model does not attempt to predict the precise outcome of a battle. Only a few critical factors are considered for each of the battle outcomes. Algorithms based on terrain mobility, combat power ratio, friendly and enemy missions, and time-of-day (day or night operations) are used to determine the time duration of engagements and required movements, and the attrition experienced

by each of the opposing forces. These factors and battle outcomes are of primary importance to planners. They are widely used for training at the Command and General Staff College and as planning factors during division and corps exercises.

The model used in OPT requires that the combat mission be defined for each side (Packard, in publication). Missions to choose include attack, prepared defense, hasty defense, delay, and movement to contact. Meeting engagements are not allowed since their attrition projections are uncertain and deliberate planning for them should not be done. Defensive missions may not be assigned to both sides for a single segment.

One of three combat roles also needs to be specified by the user for the units. "Close combat" should be assigned when units will be engaged in close-in fighting within 1000 meters or direct support (DS) artillery for those units. A "support" role should be specified when general support (GS) units provide supporting fires to the engagement from outside of 1000 meters. A "reserve" role is used when units are not engaged but are available to be committed in a future segment. The OPT-computed attrition effected by support units is half of the close combat attrition. When units are in a reserve role, they receive no attrition or loss of combat power.

Base combat power values for each unit type are assigned default values based on CGSC materials (1989). The user can revise these values as desired. Initial combat power is derived from the current situation strength multiplied by the base combat power. Combat power of close combat units is multiplied by 2 if attacking or if in prepared defense.

Attrition is computed in the model separately for attacker and defender as a loss rate and surviving fraction. The following equations apply when the units are directly in close combat, except when either side's mission is "delay." In "delay" the loss rate is half of the calculated rate.

Attacker: **Loss rate = a * $e^{(b*CPR)}$ * AF**

Surviving fraction = 1 - loss rate

Where **e**: natural logarithm base (2.7182818 . . .)

CPR: starting combat power ratio of attacker to defender

AF: attrition factor

For CPR $\leq$ 1.4, **a** = 0.5408 and **b** = -0.4788.

For CPR > 1.4, **a** = 0.3681 and **b** = -0.2017.

Defender: **Loss rate = (1 - (a + (b * CPR))) * AF**

Surviving fraction = 1 - loss rate

For CPR $\leq$ 1.4, **a** = .9835 and **b** = -0.1153

For CPR > 1.4, **a** = .9338 and **b** = -0.0710.

Losses for units in a "support" role are half of the losses of close combat units.

Default attrition factors are based on look-up tables representing a curvi-linear function of combat power ratios and whether the attrition is applied to the attacker or defender. For example, if an attacker enjoys a 3:1 combat power ratio, then the AF is 0.2010; if it is 5:1, then the AF goes down to 0.1342; and if it is only 1:2, then the AF increased to 0.4256. Attritions for delay operations are computed at half these values. Attrition factors can also be adjusted by the user.

Movement times are computed by considering distance, rate, time of day, and any user-identified delays. Distance to be moved is a user input to OPT. Movement rates are calculated as a function of combat power ratio, type of terrain, and type of defense. Type of terrain is prespecified from terrain data for the map area into go, slow-go, and no-go terrain (CGSC, 1989). Fastest rates occur against unopposed movement, next fastest against delay, next against hasty defense, and slowest against prepared defense. The base rates were taken from materials on the command estimate (CGSC, 1989) and a simulation system (First Battle B-C, 1987). The nighttime rate is one half of the daytime rate. Daytime and nighttime are determined based on BMNT (beginning of morning nautical twilight) and EENT (end of evening nautical twilight). The movement rate tables can be edited by the user to adjust the movement calculations.

OPT is designed so that other algorithms can be substituted as the Army's doctrinal knowledge base grows. Many potential combat multipliers are not included in the algorithms (e.g., morale, leadership, deception) because their contribution to combat power is not known a priori, and there is no clear-cut knowledge of the combat effects of these variables. Even though the model does not directly consider all factors that serve as combat multipliers, there is a capability for the user to apply his expert judgment to adjust system-derived combat power values.

Visualization

Existing capabilities of the Workstation combined with the graphics and textual capabilities of OPT support visualization of

the battlefield. For example, the planner is aided in visualizing the current and future disposition of friendly and enemy elements in relation to the terrain and battlefield geometry via graphic displays. OPT allows the planner to see a semi-automated display of the disposition of friendly and enemy forces on the battlefield. OPT also facilitates visualization of the time and space relationship of units along particular portions of the segments and routes.

Visualization will also be enhanced since "snapshots" of situations during the COA are automatically recorded and stored to allow immediate access as required. This bookkeeping of visualization and war-gaming activities can be used for visually-oriented presentations and production of planning products.

Advantages of OPT

Simple analytical algorithms should enhance human performance for a number of reasons. First, the algorithms require minimal prompting for input parameters and data from the user; the user inputs only critical data that will vary for the particular situation. Second, the simplicity of the mathematical computations provides near-immediate feedback to the planner. The use of simplified algorithms (and a model of combat) expedites the numerical operations required for war-gaming. This provides more time for analysis and allows the planner to "maintain his train of thought" without being slowed down by computer operations. Third, simple algorithms allow the planner to understand exactly what they represent. He can decide when to modify his use of OPT when the combat situation requires a different approach than provided by the OPT algorithms. Fourth, the analytical support provided by OPT decreases "bookkeeping" activities (i.e., calculations) for the user. Calculations are made and saved automatically allowing more frequent and detailed estimates. This gives the planner more time to perform other activities. The result should be higher quality decisions (Perkins, Flanagan & Fallesen, in publication).

Automated capabilities of OPT provide effective and timely support of quantitative development, analysis, and comparison of COAs. Time savings and decreased workload resulting from automation of simple mathematical calculations and quantitative projections provide the planner with more time to conduct a thorough analysis in the comparison of COAs.

Functional Capabilities of OPT

Functional capabilities selected for design and development were those that allowed demonstration of the OPT concept in a timely and cost effective manner. A short development period made it possible to obtain feedback from users and tool experts early in the developmental cycle. Table 2 presents the critical functional capabilities and features that have been implemented in OPT. The following will provide an overview of the capabilities and their interrelationship. The description of functional characteristics is based on an example assuming the creation of a COA from the current situation. The description is not intended to serve as a "user's guide"; furthermore, the example does not indicate a required procedure for utilizing OPT. OPT is a flexible tool and may be used as desired by the planner.

Table 2

User-support Features and Functions of OPT.

OPT supports the user in doing the following:

Creating a COA using either the current situation database or previously created COAs.

Naming COAs and routes.

Entering a route start time.

Assigning missions for friendly and enemy forces.

Designating start and end points of a route and segments of a route.

Choosing the level of detail for analysis (number of routes, number of segments per route).

Inserting, deleting, or modifying start and end locations for a route or segment.

Recording narrative or descriptive information for segments, routes, and COA.

Selecting friendly and enemy units involved in segments.

Assigning mission roles (e.g., close combat) while arraying friendly and enemy forces on the map display.

Displaying raw (i.e., baseline and default) combat power (CP) for a unit.

Table 2 continued

Modifying planning factors for movement.

Modifying travel time (e.g., add a delay factor) in a segment based on factors not considered in the time calculation algorithm.

Modifying mission related CP values to account for force multipliers not considered in the attrition algorithm.

Repositioning friendly and enemy units on the display.

Highlighting units displayed on the map for a segment.

Viewing a timeline of mission assignments for individual friendly and enemy units throughout a COA.

Adjusting attrition rates.

OPT does the following:

Calculates and displays distance travelled by user-designated units on a route or segment.

Calculates and displays time required on user designated units to travel on a route or segment (based on trafficability of terrain, mission type, and CPR).

Calculates and displays the proportion of distance that is go, slow-go, and no-go on a route or segment (based on cross-country mobility data).

Calculates and displays CP and relative combat power (RCP) for friendly and enemy forces performing designated missions for a segment.

Estimates friendly and enemy attrition for a segment, route, and COA (based on factors related to mission type, CPR, and unit role)

Calculates and displays summary data for projected battle outcome measures for a particular COA.

Calculates and displays summary data (e.g., attrition) for projected battle outcome measures to allow comparison of COAs.

Displays a timeline legend with day-night indications for visualizing the relative positioning of units on multiple routes during a COA.

Repositions units assigned to the route for subsequent segments.

Designating Courses of Action and Branches

OPT is accessed by the user when he selects the "Tool" function icon or window (i.e., clicks on the icon using the mouse) at the top of the Workstation display. The "Ops Planning Tools" choice is then selected from the Tool window menu. The user is then presented with a box labelled "Current Situation." Figure 1 provides an example of this display where three basic COAs have been previously defined and two of those have COA variations ("branches") defined. The user can create a new COA by clicking on the "Current Situation" (or any previously defined COA) and selecting the "Create Branch" option from a pop-up menu of COA related options. The keyboard is then used to enter a name for the COA. At this point, the user may want to review situational and reference data as desired. This can be achieved while the OPT window is open because Workstation supports a multiple windowing and task environment. The user may also want to reconfigure the map display. By clicking on the map background to call-up the Map Option Menu, it is possible to change the map scale, the type of map background, friendly and enemy units that are displayed, and battlefield geometry. A cross-country mobility (CCM) map background was developed specifically for OPT and is the default background when OPT is entered. This allows the user to identify and locate go (green), slow-go (yellow), and no-go (red-brown) terrain very easily during the route planning process.

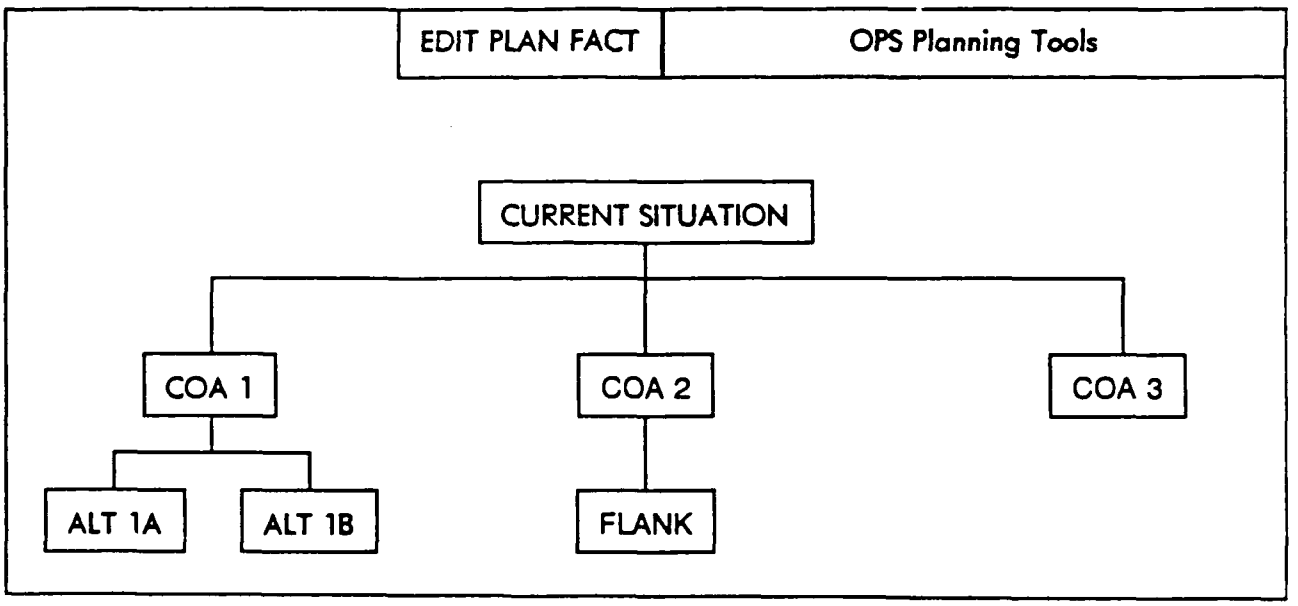

Figure 1. OPT Top Level Display.

Designating Routes

Once the map display is set-up as desired and the information has been reviewed and assimilated, the user is ready to create routes and segments. The "Create OPT Route" option of the Map Option Menu is selected, then the user enters the name of the route, enters a start time for the route, and selects friendly and enemy missions for the start of the route. A sample of the Route Definition window is shown in the center of Figure 2. After these "set-up" related activities are performed, the user can specify the location of the route by clicking on the map to indicate the start and end points of the individual segments of the route. The first click on the map designates the start of the route and first segment. A second click on a separate portion of the map indicates the end of segment 1 and the start of segment 2. The user continues to designate segments until the last segment of the route has been designated. The user does not have to be extremely careful in initially laying out the route. Start and end points of segments can be changed easily at any time during the planning process. Also, segments can be deleted, and new segments created at any time. All calculations are automatically redone to reflect any changes as they are made. Thus, a user can quickly generate a route with few segments to perform a quick visualization and war-gaming analysis. If the COA of which the route is a part warrants further, more detailed analysis, the initial segments can later be divided to produce a route with many segments.

Two factors govern the amount of detail included by the planner in laying out routes. First is time. The planners may not have the luxury of spending as much time on the analysis as they want. OPT can be used to provide quick results. Second, each route segment represents an identifiable, separable portion of the battlefield that is to be war-gamed and visualized. Therefore, the type of operation being planned influences the complexity of routes. In the most detailed analysis, each change of force structure or mission (BLUFOR or OPFOR), or change in direction of planned movement is reason to create a new segment. This allows each change to be individually war-gamed and analyzed.

OPT supports the development and war-gaming of multiple routes for a single COA. For example, a COA could contain a main attack route, two supporting attack routes, a counter-attack route, and routes representing unopposed movement (e.g., to assembly areas), rear operations, and deep operations. The user can develop these multiple routes when he wishes; before specifying force arrays and performing war-gaming, after a previous route has been completely or partially war-gamed, or any combination.

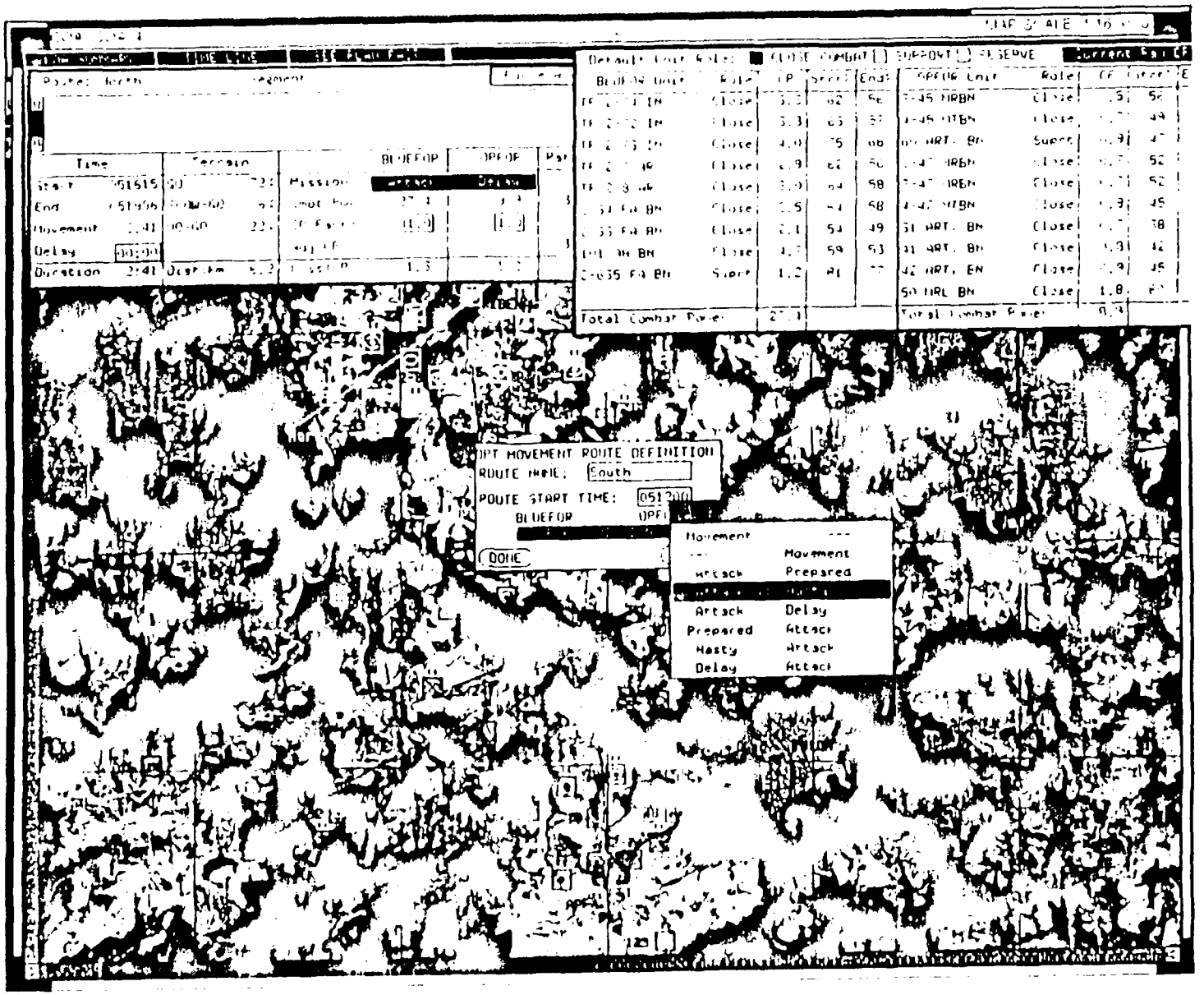

Figure 2. OPT Route Definition, Segment Report, and Force Array.

Arraying Forces and Wargaming

After the route or segments of a route have been developed, the user can array forces. The user clicks on the desired segment of a route and a pop-up menu appears as shown in Figure 3. The user selects the "Array Forces" option from this menu. Enemy and friendly forces must be arrayed for at least the initial segment. This is done by clicking on units (friendly and enemy) that will be engaged in the segment. A Force Array Table, shown in Figure 2 (top right) and Figure 4 (bottom), is presented on the screen and allows the user to assign the role of units as either a close combat, support, or reserve role. The table also presents combat power and percentage strength data for enemy and friendly units. The Force Array Table has interactive capabilities that facilitate assignment and reassignment of unit roles.

OPT provides near immediate war-gaming results on each segment. Once units and missions are assigned for enemy and friendly forces, OPT provides war-gaming measures for movement duration, linear distance travelled between the start and end of each segment, and estimated attrition for combat power, Figure 2 and Figure 4 (top left). Simple analytical algorithms calculate combat power losses based on CPR, missions, and unit role. If combat power values provided by OPT are considered inappropriate by the user, he can adjust the values (see Figure 5). If desired, the user can also get an estimate of combat power that is not dependent on a particular mission assignment. Movement time between two points may be affected by factors not included in mathematical algorithms. The planner can, therefore, use his military judgment to make adjustments in travel time by adding a delay time. The user may provide a narrative documentation for each segment and route making it easier to remember key facts related to development of the route.

After the initial segment of a route is created, OPT automatically facilitates the user's capability to develop (and analyze) subsequent segments of a route. The force array, unit roles, and relative position of friendly and enemy unit positions are automatically used on subsequent segments of a route until changed by the user. This minimizes unnecessary data entry by the user; however, if there is a need to change values of those parameters then OPT provides this flexibility. Flexibility in analysis and war-gaming is also provided by the capability of the user to modify the route at any time during development and analysis. This capability is critical for allowing the user to conduct a more detailed analysis after a preliminary "quick and dirty" analysis. This could be accomplished by inserting, deleting, and modifying segments in the route. The route and segment modification capability is important for development of contingency plans.

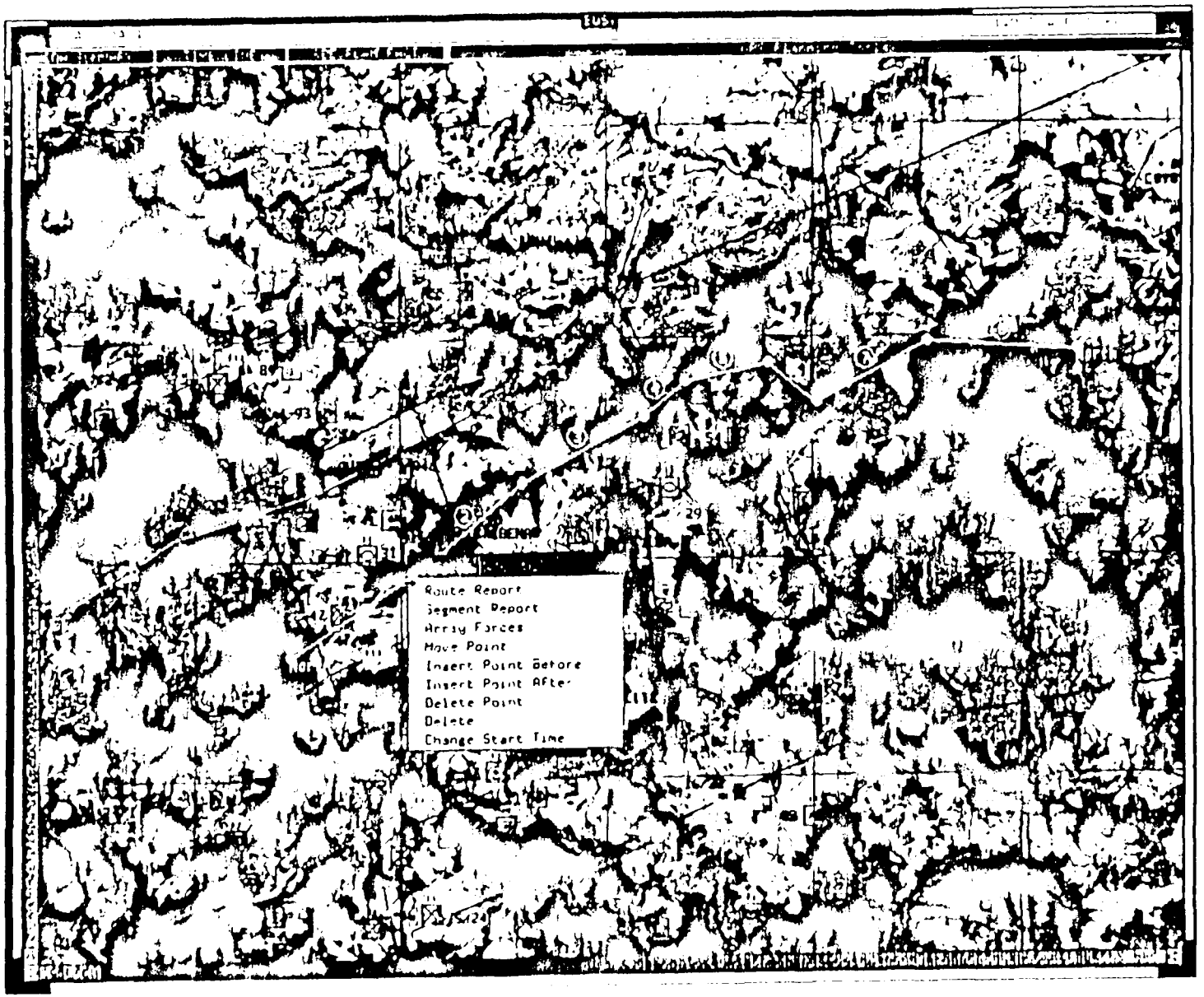

Figure 3. OPT Route Menu.

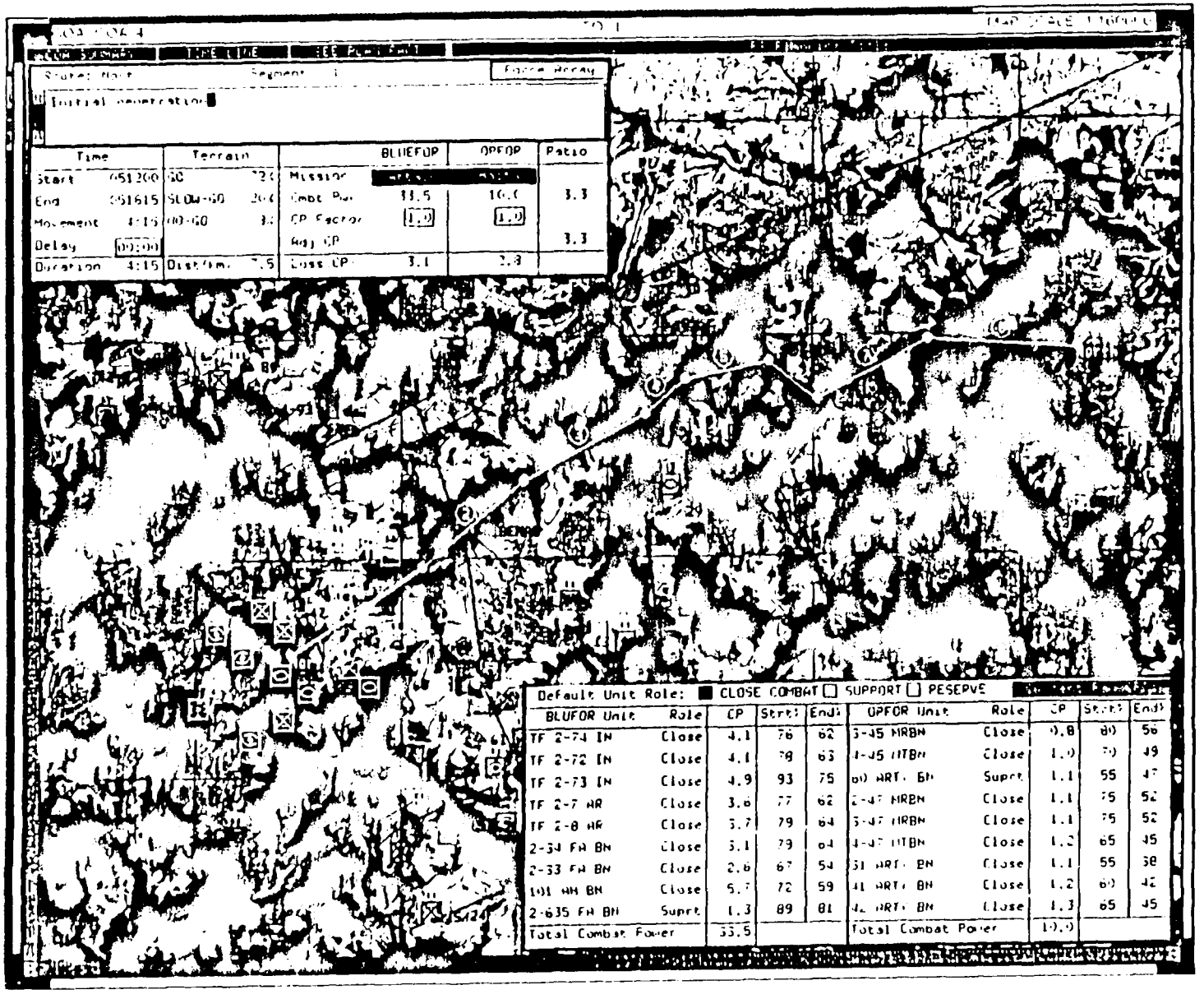

Figure 4. OPT Segment Selected with Segment and Force Array Reports.

OPT PLANNING FACTORS EDIT Enabled

ATTACKERS MOVEMENT RATE (km per hour)

■ Unopposed ☐ Prepared Defense
☐ Hasty Defense ☐ Delay

CPR	GO		SLOW-GO		NO-GO	
	Std	Curr	Std	Curr	Std	Curr
0.25	24.00	24.00	16.00	16.00	1.00	1.00
0.50	24.00	24.00	16.00	16.00	1.00	1.00
0.75	24.00	24.00	16.00	16.00	1.00	1.00
1.00	24.00	24.00	16.00	16.00	1.00	1.00
2.00	24.00	24.00	16.00	16.00	1.00	1.00
3.00	24.00	24.00	16.00	16.00	1.00	1.00
4.00	24.00	24.00	16.00	16.00	1.00	1.00
5.00	24.00	24.00	16.00	16.00	1.00	1.00

Movement Rate Adjustment Factor [1.0]

ATTRITION RATES

Delay = 1/2 Rates

■ Attacker
☐ Defender

CPR	Std	Curr
0.25	0.4798	0.4798
0.50	0.4256	0.4256
0.75	0.3776	0.3776
1.00	0.3350	0.3350
2.00	0.2459	0.2459
3.00	0.2010	0.2010
4.00	0.1642	0.1642
5.00	0.1342	0.1342

Adj. Factor [1.0]

BASE COMBAT POWER

BLUE Force Units			RED Force Units		
Unit Type	Std	Curr	Unit Type	Std	Curr
Armor Bn (M1)	3.00	[3.00]	Tk Bn (T-80) TR	1.56	[1.56]
Armor Bn (M1A1)	3.15	[3.15]	Tk Bn (T-80) MRR	2.00	[2.00]
Armor Bn (M60A3)	2.25	[2.25]	Tk Bn (T-72) TR	1.20	[1.20]
Inf Bn (M) (M2)	2.00	[2.00]	Tk Bn (T-72) MRR	1.55	[1.55]
Inf Bn (M) (M113)	1.50	[1.50]	Tk Bn (T-64) TR	1.44	[1.44]
Atk Heli Bn (AH-1)	3.00	[3.00]	Tk Bn (T-64) MRR	1.86	[1.86]
Atk Heli Bn (AH-64)	4.00	[4.00]	Mtrzd Rifle Bn (BTR)	1.00	[1.00]
MLRS Btry	2.00	[2.00]	Mtrzd Rifle Bn (BMP)	1.50	[1.50]
Arty Bn (Div) 155mm	2.00	[2.00]	Atk Heli Sqdn	2.00	[2.00]
Arty Bn 203mm	2.00	[2.00]	Anti Tank Bn	1.00	[1.00]
Arty Bn (C) 155mm	1.50	[1.50]	Arty Bn	2.00	[2.00]
Cav Sqdn (Div)	1.50	[1.50]	MRL Bn	3.00	[3.00]
Cav Sqdn (ACR)	2.75	[2.75]	Div Recon Bn	1.60	[1.60]

Figure 5. OPT Planning Factors Edit Menu.

OPT enhances the capability of the user to visualize the disposition of friendly and enemy forces as they are arrayed on the battlefield. The user can move or reposition units on the map by clicking on the desired unit, selecting the move option from a pop-up menu, and clicking on the map at the desired location for the unit. As successive segments of a route are being developed and analyzed, the system will automatically move units relative to the starting point of each segment. The user can graphically move units for any segment and that relation will be maintained until changed by the user. By selecting any segment, the user can obtain a graphic display of units for that segment. By successively selecting segments, the user can obtain an animated display of the time and space relationship of friendly and enemy elements. When a segment is selected the units arrayed on that segment are highlighted. An example of this display is shown in Figure 4. The user may also reassign unit roles or force missions on any segment as required.

Wargame Results

The measures calculated by OPT during development of routes and segments can be collapsed or rolled-up to provide summary measures. For example, a Route Summary Table presents the war-gaming measures for all segments composing the route. A COA Summary Table provides the user with the critical measures for all routes of a COA. Samples of these displays are shown in Figure 6. When a COA is selected from the top level display, Figure 1, one of the options is COA Compare. This provides a comparison of all designated COAs and allows the user to designate a COA to serve as base for relative comparisons. These latter data are critical for comparing, deciding on, and justifying a COA. A sample of this display is shown in Figure 7.

Timeline

A timeline feature of OPT enhances the users capability to visualize time and space relationships on the battlefield. A "Timeline" button on the Title Bar of the OPT Window allows the user to turn on the capability. A timeline appears underneath the map on the OPT window with start and end times for the timeline being the start and end times for the COA. Figure 8 provides an example of this display. The timeline can be used two ways. The user can use it to determine the location of forces along the routes of the COA at a particular time. The user clicks on a particular time (and date) and a timeline hatch mark will appear along each route of the COA. Alternatively, it can be used to determine at what time units will be at a particular location on the route or segment. The user clicks on a particular location along the route and the timeline displays the time when units would be at that location.

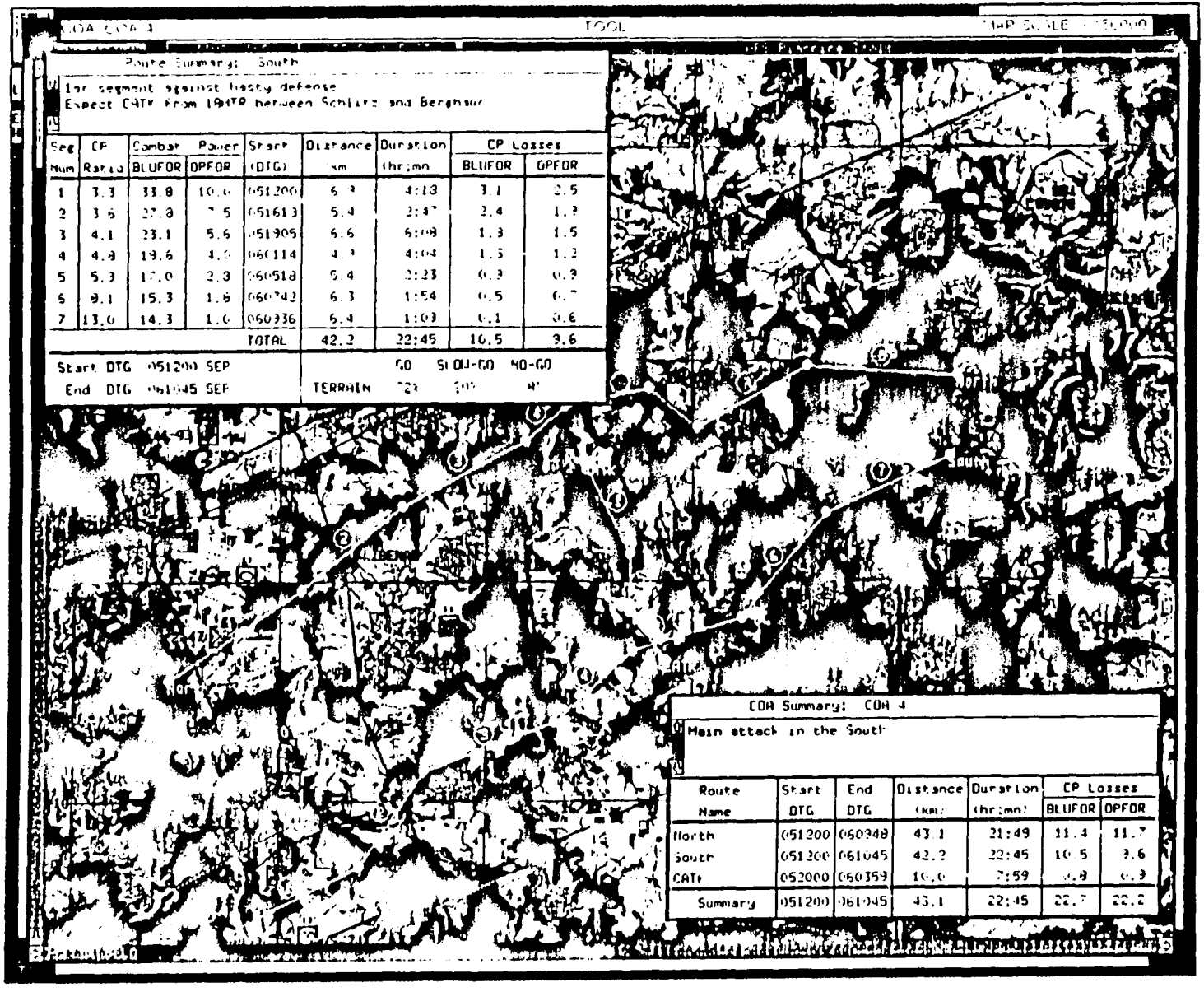

Figure 6. OPT Route and COA Summary Reports

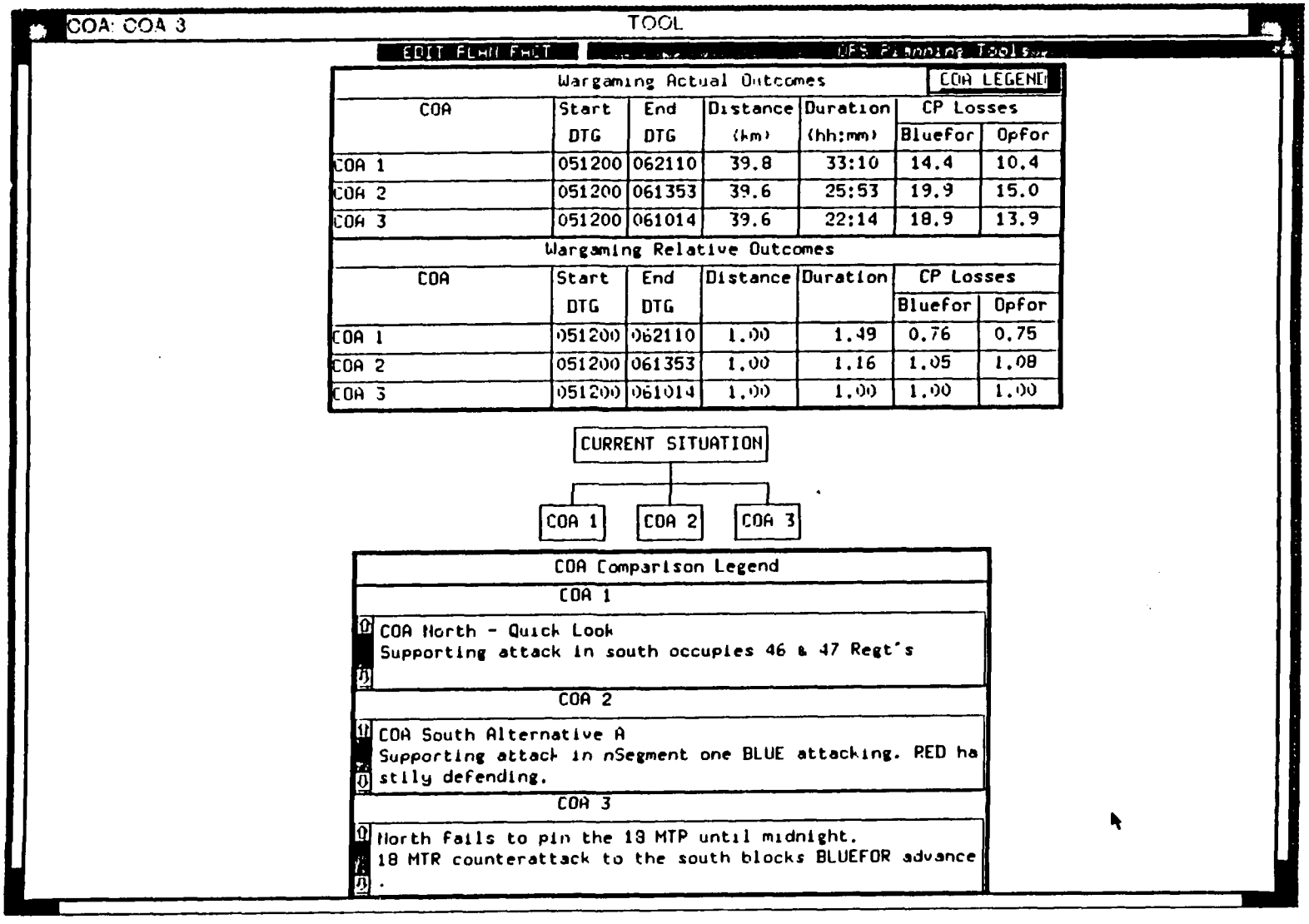

Figure 7. OPT COA Comparison Report

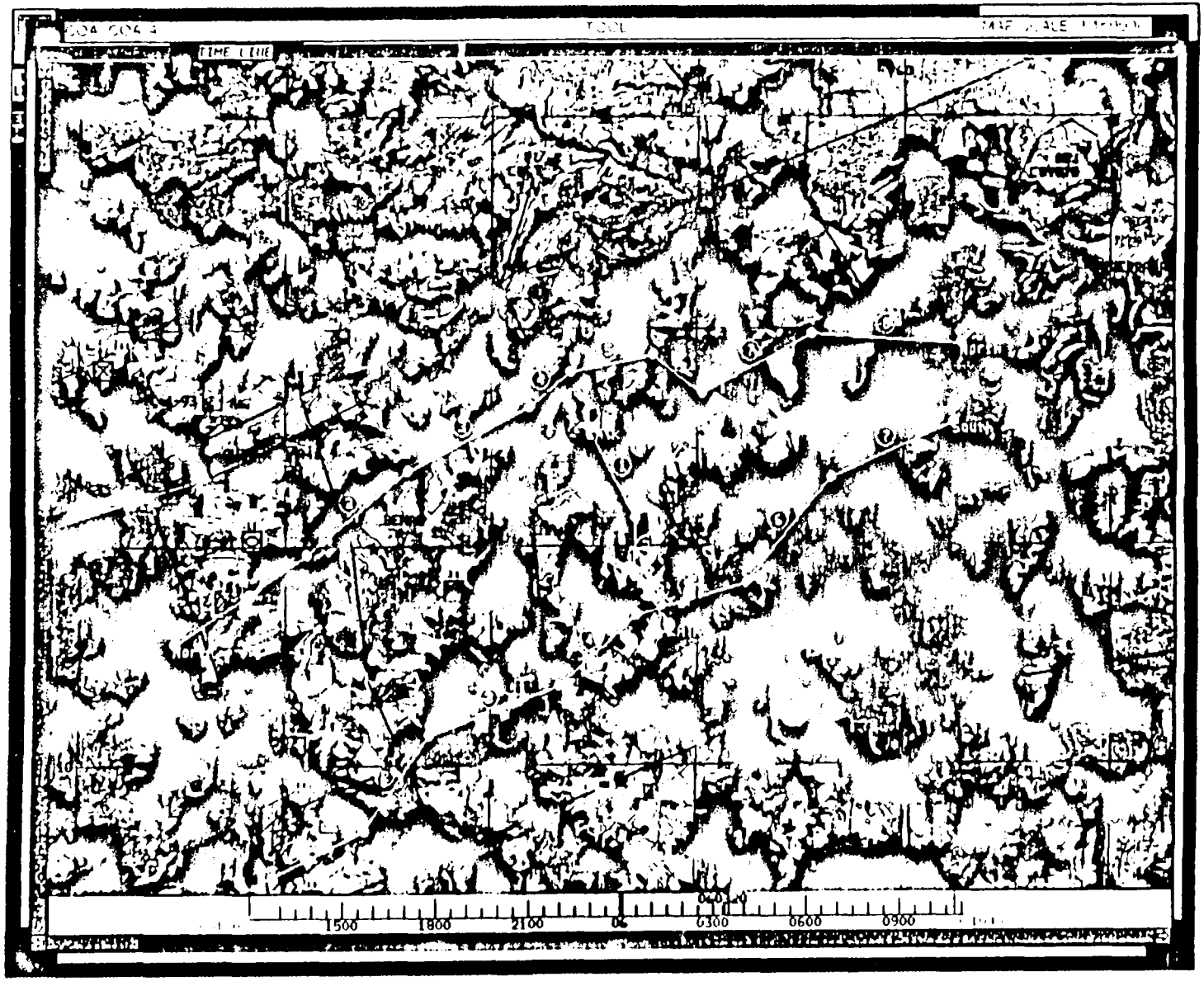

Figure 8. OPT Timeline Display.

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